TITLE

OLED DISPLAY AND PIXEL STRUCTURE THEREOF

BACKGROUND OF THE INVENTION

Field of the Invention

5   The present invention relates to an active matrix organic light-emitting diode (OLED) display and in particular to a less costly and easily manufactured active matrix OLED display.

Description of the Related Art

10   Organic light-emitting diodes (OLED) are active lighting elements, which, when receiving a voltage, inject an electron into an organic semiconductor through a cathode, and into an electron hole through an anode. The electron and the electron hole form an electron-hole

15   pair in an organic thin film, and produce photons by radiative recombination.

Compared with a conventional inorganic LED, the OLED is easily formed on large panels. As well, displays utilizing OLEDs require no backlight module, such that

20   process is simpler and costs are reduced.

OLEDs can be applied to small panels such as those in personal digital assistant (PDA) or digital camera applications.

In conventional OLED display, a pixel is formed by

25   two thin film transistors (TFT). The first TFT switches the pixel, and the second TFT controls the power applied to the OLED. Two types of common TFTs are applied to OLED displays, amorphous silicon thin film transistor (a-

Si TFT) and low-temperature Poli-silicon (LTPS) TFT. The carrier mobility of the LTPS TFT is 100 times that of a-Si TFT, such that the LTPS TFT can supply the OLED with sufficient current, making it a better choice as a

5   control element of the active matrix OLED display. However, manufacture of the LTPS TFT is very complicated, lowering product reliability and increasing costs.

SUMMARY OF THE INVENTION

The pixel structure of the present invention

10   comprises a first transistor, a storage capacitor, a second transistor and an OLED. The first transistor has a gate terminal coupled to a scan signal and a drain terminal coupled to a data signal. The storage capacitor has two terminals coupled to a source terminal of the

15   first transistor and a reference node, which has a second voltage. The second transistor has a gate terminal coupled to the source terminal of the first transistor and a source terminal coupled to the reference node. The OLED has a cathode coupled to a drain terminal of the

20   second transistor and an anode coupled to a first voltage, higher than the second voltage. The second transistor is an amorphous silicon thin film transistor (a-Si TFT), and an equivalent channel width/length (W/L) ratio of the second transistor exceeds 10.

25   ## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention can be more fully understood by reading the subsequent detailed description and

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examples with references made to the accompanying drawings, wherein:

Fig. 1a shows the first embodiment of the present invention;

Fig. 1b shows the second embodiment of the present invention;

Fig. 2 shows electrical properties of the a-Si and LTPS TFTs;

Fig. 3 shows the structure of the a-si TFT;

Fig. 4 shows electrical properties of an a-Si TFT with an equivalent channel width/length (W/L) ratio greater than 10 and a common a-Si TFT;

Fig. 5a shows the third embodiment of the present invention;

Fig. 5b shows the fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 shows a first example of the present invention. The pixel structure comprises a first transistor (switching transistor) M1, a storage capacitor C1, a second transistor (driving transistor) M2 and an organic light-emitting diode (OLED). The first transistor has a gate terminal coupled to a scan signal SCAN and a drain terminal coupled to a data signal DATA. The first transistor M1 controls the transmission of data signal DATA according to the scan signal SCAN. The storage capacitor C1 has two terminals coupled to a source terminal of the first transistor M1 and a reference node. The reference node has a second voltage

V2. The second transistor M2 has a gate terminal coupled to the source terminal of the first transistor M1 and a source terminal coupled to the reference node. The OLED has a cathode coupled to a drain terminal of the second transistor M2 and an anode coupled to a first voltage V1. The first voltage V1 exceeds the second voltage V2. The second transistor controls the current through the OLED according to the data signal DATA. The second transistor M2 is an amorphous silicon thin film transistor (a-Si TFT), and an equivalent channel width/length (W/L) ratio of the second transistor M2 exceeds 10.

The second voltage V2 is a ground or a low voltage.

The first voltage is a power supply voltage.

Fig. 1b shows a second embodiment of the present invention, wherein the OLED is connected to the source terminal of the second transistor M2 via the anode, and connected to the first voltage V1 via the cathode. The drain terminal of the second transistor M2 is connected to the reference node. The second voltage V2 exceeds the first voltage V1.

When a voltage of the scan signal SCAN received by the gate terminal of the first transistor M1 exceeds an active voltage of the first transistor M1, the first transistor M1 transmits the data signal DATA to the storage capacitor C1. Then, when a stored voltage Vg in the storage capacitor C1 exceeds an active voltage of the second transistor M2, the second transistor M2 transmits an actuation current through the OLED according to the stored voltage Vg. Thus, brightness of the OLED is controlled by the data signal DATA.

Applied with the same voltage, the a-Si TFT transmits less current than the LTPS TFT transmits, however, by increasing an equivalent channel width/length (W/L) ratio of the a-Si TFT, sufficient actuation current is provided to actuate the OLED.

Table 1 shows a simulation result of current needed to actuate display. As shown in Table 1, the highest current request for actuating the OLED is about 6.13µA. Thus, if the a-Si TFT can supply a current with 6.13µA, it can be applied in an active matrix OLED display.

Table 1

Maximum brightness of display(cd/m²)			Required brightness from OLED (cd/m2)	Light efficiency of OLED (cd/A)	Current required to activate OLED (µA)
White light applied in mobile phone display (60)	R	8	450	4	0.65
	G	6	900	15	0.34
	B		150	4	0.22
White light applied in notebook display (300)	R	0	1687	4	6.13
	G	80	3374	15	3.3
	B	0	562	4	2

As shown in Fig. 2, by raising input voltage above 13v, the a-Si TFT can output a 6.13µA current. However, a high input voltage hastens degradation of the a-Si TFT, as shown in the following current function of the TFT:

$$I_D = \frac{1}{2} \cdot \mu \cdot k \cdot \left(\frac{W}{L}\right)(V_{GS} - V_{th})^2$$

I_D is output current, μ carrier mobility, V_{GS} input voltage, V_{th} threshold voltage, W channel width, and L channel length. Accordingly, the output current can be raised by increasing carrier mobility, equivalent channel width/length (W/L) ratio, or input voltage. Because the carrier mobility of the a-Si TFT is fixed between 0.5~1, it is difficult to raise the output current by increasing carrier mobility, and raising input voltage hastens degradation of the a-Si TFT. Thus, the optimum method of raising output current is to increase the equivalent channel width/length (W/L) ratio. Fig. 3 shows a structure of an a-Si TFT, comprising a substrate 12, source terminal 20, drain terminal 22, channel 24, gate isolation layer 16, and gate terminal 18. W is channel width and L channel length. In Fig. 4, when the equivalent channel width/length (W/L) ratio equals 10, the a-Si TFT outputs a 6.13 µA current by inputting only 7 volt input voltage. As to current leakage, performance of the a-Si TFT is superior to an LTPS TFT. Thus, the a-Si TFT can be applied in an OLED display by raising the W/L above 10. The less costly a-Si TFT commensurately reduces the price of the active matrix OLED display.

Parallel connection of two driving transistors reduces the equivalent channel width/length (W/L) ratio requirement. Fig. 5 shows the third embodiment of the present invention, which comprises a first transistor (switching transistor) M1, a storage capacitor C1, a second transistor (driving transistor) M2, a third

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transistor (driving transistor) M3 and an OLED. The first transistor has a gate terminal coupled to a scan signal SCAN and a drain terminal coupled to a data signal DATA. The first transistor M1 controls the transmission of data signal DATA according to the scan signal SCAN. The storage capacitor C1 has two terminals coupled to a source terminal of the first transistor M1 and a reference node. The reference node has a second voltage V2. The second transistor M2 and the third transistor M3 are connected in parallel. The second transistor M2 and the third transistor M3 have gate terminals coupled to the source terminal of the first transistor M1 and source terminals coupled to the reference node. The OLED has a cathode coupled to drain terminals of the second transistor M2 and the third transistor M3 and an anode coupled to a first voltage V1. The first voltage V1 exceeds the second voltage V2. The second transistor M2 and the third transistor M3 control current through the OLED according to the data signal DATA. The second transistor M2 and the third transistor M3 are an amorphous silicon thin film transistor (a-Si TFT), and equivalent channel width/length (W/L) ratios of the second transistor M2 and the third transistor M3 exceed 5.

The third embodiment reduces the W/L ratio requirement by parallel connection. When two driving transistors are connected in parallel, the W/L ratio requirement is only 10/2=5. The relation between the

amount N of the driving transistors and equivalent

channel width/length (W/L) ratio R is $R \geq \dfrac{10}{N}$.

The second voltage V2 is a ground or a low voltage, and the first voltage is a power supply voltage.

Fig. 5b shows a fourth embodiment of the present invention, wherein the OLED is connected to the source terminals of the second transistor M2 and the third transistor M3 via the anode, and to the first voltage V1 via the cathode. The drain terminals of the second transistor (driving transistor) M2 and the third transistor (driving transistor) M3 are connected to the reference node. The second voltage V2 exceeds the first voltage V1.

The present invention can also constitute display comprising the pixel structure disclosed.

The present invention utilizes a less complex TFT to control the signal of the active matrix OLED display, decreasing costs thereof.

While the invention has been described by way of example and in terms of the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. To the contrary, it is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in the art). Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.